

EXTRACT FROM
A PERSONAL HISTORY OF
H.M. NAUTICAL ALMANAC OFFICE

30 October 1930 - 18 February 1972

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PART 2: AT GREENWICH 1936 – 1939

CHAPTER 4

Change and expansion

Changes in administrative responsibility for the N.A.O.

It is not possible to recall, either in order or in detail, the events immediately following the termination of Comrie's appointment. I was appointed Acting Superintendent and then there were consultations with the Astronomer Royal (H. Spencer Jones), with the Hydrographer of the Navy (Rear-Admiral J. A. Edgell), and with various people in Civil Establishments Branch of the Admiralty. Edgell asked for reports on various aspects of the Office and its staff, which I duly prepared and sent to him with excessive formality (as I recall with humility!). There was much to do.

All the staff paid by Comrie were dismissed, with the possible exception of Miss S. M. Burrough, who was partially paid as a temporary member of the staff; she soon accepted an offer by Comrie of a post in the Scientific Computing Service. The rest of the staff, relieved of their temporary work on Comrie's special jobs, such as "Winds", were brought back to normal work, and continued with the minimum direction from myself. A. J. and S. G. Daniels, together with Eric Smith, worked on the preparation of the *Nautical Almanac*, and were largely undisturbed. Richards and I were engaged on the preparation of the 1940-1960 heliocentric ephemerides. The person who had the main responsibility for the 'routine work' was W. A. Scott, and his experience was invaluable. He was assisted by Miss M. R. Rodgers, a recently entered Junior Assistant. They were magnificent, though I certainly did not give them adequate credit at the time; they (with assistance from Smith and Carter) saw to it that the junior staff were fully employed and supervised.

There appeared to be little surprise among the staff at the Admiralty's investigation and its outcome. Certainly there was no criticism of the termination of Comrie's appointment, and I received much sympathy and complete support in the difficult position in which I was placed.

The first decision, taken immediately after the termination of Comrie's appointment, was to make the constitutional change by which the Office became responsible to the Admiralty through the Astronomer Royal and the Hydrographer, instead of directly through the Hydrographer. The Admiralty decreed that the Office should be part of the Royal Observatory. The particular phrase used was something like "The Nautical Almanac Office will in future be under the direction of the Astronomer Royal". Although there was a gradual change towards full integration into the Observatory, the original arrangement (which lasted until much later than 1949 when the Office became physically part of the Royal Greenwich Observatory) was that the Office was a separate establishment under the direction of the Astronomer Royal. As such it continued to have a separate vote in the Navy Estimates, and there was little contact of any kind with the Observatory other than administrative — that is formal communications to and from the Admiralty went via the Astronomer Royal, and the

Secretary and Cashier took over the very minor accounting from his opposite number (C. E. Borrie) in the Royal Naval College. The only other contacts, apart from a few personal requests for advice on computing techniques from the Chief Assistants (W. H. M. Greaves and R. v. d. R. Woolley), were on the hockey field (Candler, Carter and I played for the Royal Observatory — quite a good team under Woolley's enthusiastic captaincy) and at the annual visitations, when the staff were "instructed" to volunteer to show visitors around.

I subsequently discovered that Spencer Jones had been extremely keen to have direct responsibility for the Office but had refused to accept it while Comrie was Superintendent. He took the view that its work should return (though it was, as such, never part of the Observatory) to the Astronomer Royal. He must have proposed the change as soon as he heard (from me) of the termination of Comrie's tenure of office; it was a change that had an obvious appeal to the Hydrographer and the Admiralty, in view of the appalling relations and difficulties with both Cowell and Comrie — while Spencer Jones' relations with both were excellent — and of my youth and inexperience. I was not consulted in any way and, although I put forward the strongest protest that I could muster in my weak position as Acting Superintendent (still on my old salary) when I was informed by the Hydrographer of the new arrangement, I could hardly expect my views to have any weight.

When my appointment as Superintendent came through in 1937 I noticed that the maximum of my salary scale was about £150 (I forget the exact figure) less than that of the Chief Assistants (and the professors at the Royal Naval College) to which it was supposed to be linked. It was even later when I discovered that the Astronomer Royal's salary had been increased, by at least the same amount, because of his additional responsibility. The Hydrographer (Edgell) promised that he would ensure that the maximum was revised before I reached the relevant scale-point; in fact, it was so raised.

In the early days, Spencer Jones' "direction" was — I venture to think — rather unimaginative. I was completely unused to official correspondence, and my draft report and my draft letter to the Hydrographer — signed "Your obedient servant" — were remarkably crude. But they, no doubt, created a welcome relief to Hydrographer, who had been called to task by Comrie for mixing up 'which' and 'that'. Initially, I tended to consult Spencer Jones on most establishment and administrative questions, as well as on the principles (but not technical details) of the various additional projects that the Office undertook. The consultations became less frequent as I became more experienced in dealing with the Admiralty. This trend was accentuated, owing to distance, after the Office was evacuated with the Admiralty to Bath in 1939, and owing to the Office taking on war-time projects that had little, or no, connection with the Observatory or with astronomy. Although I kept him (I hope reasonably fully) informed, it would have been unrealistic to have consulted him, or worked through him on, say, the organisation and work of the Admiralty Computing Service. He made occasional visits to the Office in Bath as an extension of his periodical visits to the Chronometer Department at Bradford-on-Avon. It was, however, often impossible to get him to give opinions or make decisions. Both then, and until he retired in 1955, I often had to assume that his silence meant consent to the proposals I made in personal discussions. (This same taciturnity was apparent when we were both officers of the R.A.S., the meetings of which provided opportunities for less formal exchanges of views on Office matters). On the whole, the arrangement worked well; I knew that I had his moral support, and (in general) his considerable influence behind my submissions to the Admiralty. On my

side, I tried to consult him as well as inform him — he may have been very wise in refraining from “interference”, though I occasionally thought that some encouragement might not have been out of place. We got on very much better together after he retired!

The work and staffing of the Office

The Office was in a most unstable state, both as regards work-load and staff — mainly due to the combination of Comrie’s initiative in undertaking new and additional (astronomical) tasks and his conflict with the Admiralty as regards the complement. The main work of the Office — the calculations for, the preparation of copy for, and the proofreading of the N.A. and A.N.A. — proceeded under the supervision of the Daniels and Scott; the fundamental ephemerides of the Sun, Moon and planets for 1940 onwards were by then available. The four main new undertakings, arising shortly before or shortly after August 1936, were:

the greatly increased occultation programme, involving the preparation and publication of an *Occultation Supplement*, as well as the calculation and publication of occultation reduction elements;

the design, calculation and publication of the *Air Almanac*;

the design, calculation and publication of tables for air navigation (the *Astronomical Navigation Tables* — known as A.N.T.s); and

the redistribution of responsibility for the calculation and publication of the apparent places of stars.

There were also a number of enquiries arising from Comrie’s activities. We kept being asked for advice on particular calculating machines — in particular by the Treasury Investigation Department. The Treasury disliked Comrie, but in 1936 it had little knowledge of ‘modern’ machines, and our advice on calculating machines was requested on several occasions. We were asked to recommend particular machines for various jobs and to report on new models. I was far from happy about this, as it seemed quite out of our orbit and it involved a great deal of work.

Another such approach in 1937, or 1938, was from the Ordnance Board, which had an armament research team at the Woolwich Arsenal, concerned with the ballistics of anti-aircraft (A.A.) gun trajectories. Hence my meeting with Dr J. W. Maccoll, who was interested in the application of the National machine to the calculation. They were using the “manual” produced in the 1914-18 war by a team of first-class mathematicians. But techniques had changed a lot, and I found a method of integrating the two simultaneous second-order differential equations at the same time on the National machine. All the multiplications and entries into the air-density and resistance tables had, of course, to be done on an auxiliary machine, but the National machine did all the numerical integration and differencing. To the accuracy required, the 11-figure accuracy of the (decimal) National could conveniently be divided into 2 x 6 figures as the first figure could be supplied by hand. With the availability of a Brunsviga 20 to do the calculating, it was possible to do a trajectory without writing, or with the least possible writing. Maccoll was very impressed and immediately ordered a machine.

[It gave me great pleasure to meet Maccoll again in 1975 at the inauguration of the new computer at R.A.R.D.E. at Fort Halstead; he had been retired for many years, but he recalled how the anti-aircraft ballistic tables had been calculated by National machines! (R.A.R.D.E. = Royal Armament Research and Development Establishment)]

These new activities will be described in appropriate detail later; their effect on the increase in the complement and in the requirements for additional equipment and accommodation will be dealt with first. Only the main outlines, and principal changes or appointments, will be included as full details of all appointments, and the appropriate complement, are on record.

The post of N.A.O. Secretary

Illogically in the circumstances, as I then and still do consider, the Hydrographer obtained Admiralty approval to second a senior Clerical Officer to act as secretary to the Office (and perhaps as my nursemaid!). It seemed unnecessary for its stated purpose of ensuring that I was familiar with Admiralty and Hydrographic Office procedures as the Astronomer Royal and his secretary were almost on the spot for consultation. The Clerical Officer (C.O.) received an allowance of £50, which could hardly have been adequate compensation for (in almost all cases) the additional journey from Central London to Greenwich; it was, however, accepted by the current senior C.O.. But since any vacancy in the Higher Clerical Officer grade was filled by the current senior C.O., changes of incumbent were very frequent as successive holders were promoted and left. What was I to do with them? Some of them became 'members' of the staff; for others it was just a step to promotion. Until August 1939 when Miss H. A. Howard was recalled to act as Billeting Officer in Bath the C.O.s were: E. T. Silk, R. Gornall, L. V. Granger, W. R. J. Brockwell, Mr Gibbs, H. A. Carrick, Miss H. A. Howard. The obvious difficulties were that there was far too little work and their training and outlook were so different.

On the whole, however, they were helpful and certainly tried to interest themselves (some more than others) in the work of the Office — particularly Silk, Granger and Miss Howard. It was a recurrent chore for me to find jobs which they could usefully do; without exception none had any mathematical or scientific background, so that they could not help with the actual work of the Office, though they did some proofreading occasionally. I had a shorthand-typist to whom I dictated letters; and it took far longer for me to discuss minor administrative matters with the C.O., to approve the draft letter of minute, and for the shorthand typist to type it, than it would have taken to dictate it directly. Eventually I started an elementary abstracting system with the intention of building up a card-catalogue of articles in certain well-defined fields. The articles to be included, and notes thereon, were made by the staff, and the C.O. did the rest. But the scheme was too ambitious and too poorly planned to be of real use — I was (and still am) ignorant of bibliographical practices and I was also too busy to devote much time to it. Although the Office certainly gained by the secondment of these C.O.s, there can be little doubt that the arrangement was not the most efficient means of achieving its object.

Silk rapidly became a valued person and was popular with the staff; after promotion he kept in touch, and turned up at the 200th birthday celebration of the *Nautical Almanac*; he died in 1976. The last person was Miss Howard, who was in the Office when we moved to Devonport House, but she did not stay very long. She was most efficient and played a large part in the organisation of the move — although she objected to the view of the hospital's mortuary from her window! She was called back to the Admiralty to act as Billeting Officer for the move to Bath. She has continued to keep in touch with some of the members of the staff then in the Office.

Initial recruitment of junior staff

At a fairly early stage a complement was agreed by C. E. Branch for the Office. The Lump Sum, from which temporary staff were paid, was much reduced but was retained, primarily to allow payments to be for “outside work” at piece-work rates. A number of staff had (by 1936) been established, including A. J. and S. G. Daniels, and some established staff had been recruited. Comrie had, however, refused to accept any grade lower than Junior Assistant, Lower Grade (J.A.(L.G.)), then roughly equivalent to Assistant Experimental Officer (A.E.O.) in the post-war scientific Civil Service. The agreed complement did allow for some Clerical Assistants, for which grade the qualifications appeared adequate for much of the more routine work of the Office (for example, operating the National machines). At, or about, this time A. E. Carter, G. A. Harding, Miss M. R. Rodgers, E. Smith were established as J.A.(L.G.). Before the expansion in 1937, however, Greaves (who was, incidentally, Comrie’s brother-in-law through Comrie’s second marriage with Miss P. B. Kitto, sister to Grace Greaves) remarked that, in the actual staff, Comrie had been replaced by a C.A. (Clerical Assistant)!

It was not my intention to attempt to refer to all staff appointments, but it is perhaps worthy of special mention that Comrie’s secretary, Miss M. M. Roberts, left a month or two after him for a post in London. She had much higher qualifications than were necessary for the shorthand-typist post that was the only one available in the Office. She was replaced by Miss V. M. Hooper who, although quite efficient at her job, had very odd religious views (she would, for example, refuse to type an excuse for not accepting an invitation if she knew that it was not precisely true). We only got her services because (as I later discovered) the Superintendent of the Admiralty pool insisted on getting rid of her. But, in spite of occasional difficulties, she served the Office pretty well until her behaviour during the war became too extreme for us to cope with.

The Clerical Assistants (not by any means the Junior Assistants, who were in a higher grade) were recruited from local schools — and by any standards they did a magnificent job. The first recruit in that grade was Miss D. J. Ifield, who with training at evening classes and inside the Office learnt to type and became assistant to my Secretary, Miss Hooper. She was one of the successes of the whole staff and became a great asset to the Office; now Mrs Barrett, she still keeps in touch. Five ‘ANTs’ were recruited to work on the *Air Navigation Tables*: Miss M. C. Scadeng (later Mrs Cooling) in charge as J.A.(L.G.); and as Clerical Assistants, Miss E. N. Histed, Miss V. H. Hitches (Mrs Rogers), Miss M. B. Simm (Mrs Goodfellow), Miss R. E. West (Mrs Hinkin) and Miss J. E. Pullen (Mrs Boas). They did a truly magnificent job and, although they worked extremely hard in very difficult conditions, seemed to enjoy it. [Miss Histed died from tuberculosis during the war; she was transferred to London from the hospital in Bath after the air raid.]

It must be said that Marion Rodgers, who supervised their initial training in computation, was the key member of the staff; apart from being extremely competent in her work, she was firm and tolerant with — let us face it — a bunch of 16-year olds straight from school. There were many more in later years — Kathleen Restorick (Mrs Hewitt) and her sister Iris Restorick (Mrs Rhodes), Miss Vera Peasgood, Miss Joyce Mounteney, Miss Jackson, ... — but Marion has kept up with them all this time.

The staff required for the third project (the A.N.T.s) were only needed for long enough to complete the tables — about three years. The printing of the 17 volumes of A.N.T.s took several years, and it was not finished until after the war, when a final volume covering latitudes to the pole was published. With the completion, I sent the Treasury an account of the expenditure — it came to less than the £5000 previously estimated. But the girls who did the work were paid miserly wages.

Expansion for air navigation

The most senior posts in the Office — as Assistants — were recruited later as a considerable expansion of the work and of the staff came in 1937, with the requirements for the *Air Almanac* (A.A.) and the *Astronomical Navigation Tables* (A.N.T.s). Apart from additional staff, it was possible to establish Richards as an Assistant and to promote Scott to J.A.(H.G.). We had a vacancy for an Assistant (in my position) for a permanent post, and I got approval for a temporary post for an Assistant for the A.A. and A.N.T.. Both were open to general competition, and were advertised through the Civil Service Commission. Although I saw the applications, and suggested 6 or 7 names (out of some 40 or 50) to appear on the short list, I was not invited to serve on the interview board, the Office being represented by the Astronomer Royal. The successful applicant was Miss F. M. McBain, who had been a vacation student. If I remember correctly, the list of other candidates was quite impressive — an Assistant post (salary maximum for a man was about £278 a year) was amply good enough to attract a first-class degree. She duly took up her appointment and served, in a part-time capacity in later years after her marriage, until she retired in 1973.

A few days after the closing date for the permanent post, an application was received for the temporary post — the applicant had been away on a skiing holiday, so missing a chance for a permanent post. We appointed W. E. Candler, a first-class honours graduate of Trinity College, who had (although I did not know this until much later) been recommended by Sir Arthur Eddington to the Astronomer Royal as a Chief Assistant. His research work was on the theory of stellar interiors, and he thought that a mixture of two (or more) values of the index number n of Emden's equation would meet the physical conditions. He served us well, supervising the early stages of the A.N.T.s and doing the exploratory investigation that was necessary. He did other jobs as well and was also encouraged to continue his research on polytropic gas spheres. Later he took a more general interest in the work of the Office. He served until 1941 when he had to be released for more urgent war-time duties — first at Orfordness and later at Helensburgh.

We had a number of Junior Assistants in the period before the war. A. E. Carter was recruited by Comrie from the Royal Observatory — the Temporary Computers at R.O. had only a limited outlet, and many took the opportunity of transferring to the N.A.O., where establishment was somewhat easier. We subsequently took on W. G. Grimwood by transfer from the R.O. where he had failed to become established and would thus be redundant; he became, still later, a J.A.(H.G.). He was transferred back in 1953 and to Cape Observatory in 1967. Direct entry from examination by the Civil Service Commission resulted in the appointment of G. A. Harding.

We then had to find accommodation for all the extra people. The Royal Naval College put at our disposal two or three rooms on the upper floor and actually provided a ladies toilet that was (almost) inside the building.

Acquisition of new calculating machines

I do not recall the details, but approval was also given for several additions to the equipment: a new decimal National machine and several desk machines, including a fast semi-automatic electric Marchant with nine multiplier keys to be used in succession for the multiplier. The new National machine was to replace the one on loan from the British Association; this was installed at University College and was used, under my distant supervision, by a computer paid by the British Association Mathematical Tables Committee — a most unsatisfactory arrangement! [The computer was then Miss S. M. Burrough, who had previously worked in the Office and in the Scientific Computing Service. She continued to have firm friendships with members of the staff of the Office; after retirement she won several first and a second prizes at the Royal Horticultural Show.]

Complete logs were kept on the National machines, mainly under the supervision of Carter. They were so prone to mechanical errors that the National mechanic became a member of the tea-club and almost a full-time member of the staff! I recall with some pride how I tracked down a series of apparently unconnected and unexplainable errors that completely defeated all the mechanics. The girls worked in two-hour shifts and I first discovered that all occurred while Miss W. D. White (later Mrs Carter) was the operator. By watching her operate, I noticed that she had a habit of resting her hand, very lightly, on the keyboard. The very slight key depression during a transfer operation would cause the number, corresponding to the depressed key, to be transferred instead of the correct one — provided it was the larger. It was no wonder that analysis of the errors failed to indicate the cause!

CHAPTER 5

New developments

The Occultation Supplement

Comrie's plans for the 1938 *Nautical Almanac* included an appendix on the Prediction and Reduction of Occultations. In August 1936 copy for this should have been ready; unfortunately, Comrie had taken all his notes on the subject, but there still remained in the Office his detailed lists of precepts, and appropriate forms, for the predictions. It was decided to defer the appendix to a separate publication. I started to draft this Occultation Supplement from scratch, conditioned to use Comrie's methods in every respect; I had expected to receive every assistance from Richards, particularly in the provision of complete illustrations of all stages of prediction and reduction. I recall my disappointment at his apparent lack of cooperation — or was it merely delay? — and my need to do most of it myself; it was quite a big job. It also involved the first publication by the N.A.O. of details of the Occultation Machine, which was designed and constructed by A. C. S. Westcott on the model of the original constructed by J. D. McNeile. There are a number of errors in the Supplement due to my lack of appreciation of the methods, and I think that I should have avoided them; but there were few numerical errors in the illustrations and no serious "bloomers". It was issued in 1937 under the title *The prediction and reduction of occultations as a Supplement to the Nautical Almanac for 1938*.

The additional work for the occultation programme involved a lot of time operating the occultation machine and much outside work on actual predictions, together with all the organisation and supervision required. Although Richards was nominally responsible, Scott was the "expert" on the machine. Miss McBain later worked on the programme and eventually took over completely. Comrie had planned it in great detail, with special tables prepared for each station, and with printed forms for the 3-figure calculations which had to be done twice — first with the approximate time from the occultation machine and then with the improved time. I, personally, had little or no connection with the programme, though I had (like everyone else) done some routine predictions. Frankly, I was not in favour of the Office devoting such a large proportion of its potential on the project, which had previously been in the hands of amateur astronomers. [The question is arguable on both sides, but the arguments are not relevant here.]

Air Almanac and Astronomical Navigation Tables

Shortly after Comrie left, two R.A.F. officers (Wing Commander W. Underhill and Squadron Leader P. H. Mackworth) from the Operational Requirements (O.R.) Division at the Air Ministry, visited the Office to continue an earlier discussion they had had with Comrie concerning the provision for astronomical navigation in the air. They were terribly enthusiastic, but were unused to numerical calculation. I recall their proposal (in writing!) for sight reduction tables giving direct solutions of the PZS triangle for every minute of arc of the three arguments; I was soon able to persuade them that this was not the answer. I had no experience of navigation by 'astro' — except a course at Cambridge in which the highlights were the determination of the

position of the Cambridge Observatory, using a sextant and reflector [artificial horizon] — and Chambers' 7-figure logarithm tables. We produced the *Nautical Almanac – Abridged for the Use of Seamen*, but it gave no indication of the means of reduction of sights. Moreover, the Office, as such, did not — and had not since the time of Maskelyne — produced sight reduction tables. This was due to the Admiralty insistence on the cosine-haversine method, and, as I later found, to an arrangement with a commercial firm for the provision of the relevant tables. The *Abridged Nautical Almanac* (A.N.A.), as it is usually called, was completely standardized and its routine preparation (mainly copying) was handled by Scott.

The demands for the R.A.F. were urgent; a form of *Air Almanac* (A.A.) for 1937, and the first volume of the *Astronomical Navigation Tables* (A.N.T.s) by the end of 1938. This did not leave very much time for planning. After a general agreement on the contents and arrangement of the *Air Almanac* and on the A.N.T.s, it was arranged that the Air Ministry should formally request the Admiralty to allow the Office to undertake the projects — with an inter-departmental payment. The Admiralty (probably the Hydrographer, but I cannot remember) arranged two meetings to discuss the projects, *technically*. There was an open meeting at the Royal Geographical Society, and an internal one, at which the representation of the Royal and Merchant Navies was much in excess of the representation of the R.A.F. and the one representative of civil aviation. The Astronomer Royal was the principal speaker at the R.G.S. meeting, leaving me to describe our, then rather tentative, proposals. My recollection is that the discussion was not very informed nor helpful — the only points raised were: the relative merit of tabulating G.H.A. stars directly or G.H.A. Aries and, what later came to be called, S.H.A. Stars; A. R. Hinks (Director of the R.G.S.) strongly objected to our invented names (e.g. Avior) for the bright southern stars for which no recognised names existed. At the internal meeting, almost all the discussion centred on the extent to which the *Air Almanac* could be used at sea, and whether its availability would affect the use of the A.N.A.. The meeting recommended that the two projects be undertaken — and appropriate approval was given without delay.

Introduction of the *Air Almanac*

The first approach to the *Air Almanac* was in the form of a cover, with constant information such as interpolation, into which an 'ephemeris' could be inserted. This was an attempt to make the actual almanac as light as possible, but the experimental edition for the last quarter of 1937 (which was produced rather quickly) was far from ideal, particularly in respect of the need to transfer the daily pages to the separate cover. This attempt failed, and it was speedily changed to a 'tear-out' Almanac, in which unwanted sheets would be torn out. There were several changes of format before the present form was adopted — itself to be considerably modified when unified with the *American Air Almanac*. With hindsight I consider that we were by no means as far-seeing as we could have been expected to be, even though neither of the two technical meetings were adequately critical.

My recollection is vague regarding the details. I knew very little about surface navigation, and nothing at all about air navigation. The only publication for comparison was the French *Ephemerides Aeronautiques*, which was based on the concept of 'vers-R.A.'; its bulk rendered it quite unsuitable, and I doubted its value. [It was later dropped and replaced by the equivalent of the *Air Almanac*.] Many of the suggestions for revision, and improvements, came from the active and fertile brain of (then Squadron

Leader) “Kelly” Barnes, who wrote the admirable *Manual of Air Navigation* and, later, inaugurated the Specialist Navigation School at Cranage (near Byley, Cheshire). It was he {or was it Mackworth?} who, requiring notations and symbols for use in the manual, demanded more-or-less instant decisions from me. Firstly, for $360^\circ - R.A.$ (in arc), for which, admittedly without large-scale consultation, we introduced S.H.A. (sidereal hour angle), now generally accepted. Secondly and less controversially, for the correction to the observed altitude of Polaris to give latitude for which we adopted Q , also now in general use. As far as I can remember we had the copy ready before the R.A.F. had made up their minds. The S.H.A. was criticised in that it was *not* an hour angle, but the critics were not faced with an instant decision; moreover, the various alternatives [e.g. left ascension] were cumbersome and unsuitable. A minor point was that of star names; the R.A.F. insisted that the stars must be named, and there were two or three bright stars in the southern hemisphere that had no classical names. Scott made a hurried search of the literature, and we adopted the names Avior and Peacock for the two stars without names.

At a somewhat later date, Scott designed a series of ‘posters’ showing the 22 stars used in the *Astronomical Navigation Tables* in the field of view of neighbouring stars. These were printed by the R.A.F. and exhibited widely.

The responsibility for the preparation of the A.A. later came under Miss McBain, but the actual routine work of preparation of copy was done under Scott’s supervision. The division of responsibilities and duties varied from time to time, according to varying demands and to the staff available.

Astronomical Navigation Tables for use in the air

The design of the A.N.T.s was rather less hurried: it was a R.A.F. requirement that provision for both stars and Sun and planets be in the same volume in a similar format. The emphasis was on single sights and single position lines, rather than on position fixing; this largely determined the arrangement. Although the main details of the A.N.T.s were sound in principle, there is a major defect in the tabulation of the stars. Mackworth did, as I recall, at one time suggest using L.H.A. Aries as argument for the stars instead of L.H.A. Star, but (with the single-star arrangement) this would have doubled the amount of tabulation required. It affords, however, the user an automatic selection of stars and a much simpler form of calculation. The device had been used for certain stars in Weems’ Star Altitude Curves, and later in the astrograph, but was not introduced into formal sight reduction tables until after the war. We did not consider the ‘Hutchings’ arrangement of tabulating the altitudes and azimuths of the optimum selection of stars for each latitude and value of L.H.A. Aries — a great pity and a regrettable oversight. I have since regretted that I did not use this opportunity for introducing the argument L.H.A. Star in the A.N.T.s. Otherwise, the A.N.T.s were a ‘model’ tabulation, with printing of a high standard and impeccably proofread. I spent much effort on typographical design of the tables and, in retrospect, I am reasonably satisfied with the result — however inappropriate for its purpose it may have been!

[The ‘Hutchings’ arrangement was used in the first edition of *Sight Reduction Tables for Air Navigation* (H.O. 249) published in 1947; but the idea had been earlier used by Hoehne.]

I was required to give the Admiralty an estimate of the total cost of producing the tables, excluding printing and binding, but including proofreading, etc.. This depended

on the method of computation, and there was a difficult choice between the use of punched-card machines (the newly developed multiplying punch could be used to interpolate trigonometric tables) and the combination of hand-methods with the “adding” National machines. We had no punched-card machines — although we had used the Multiplying Punch for a period of 6 months — and the only practical method then available for production was letter-press printing, which involved preparation of suitable copy and proofreading. So we decided to use the National machine to produce what is *sin* altitude (H). A special table in critical form to give H , which is the altitude affected with refraction at 5000 ft, was used to allow computers to enter the appropriate altitudes directly into the copy — thus avoiding rounding-off and copying errors. For the azimuths we interpolated, using the method of bridging differences, at wide intervals on the National. I am proud of the fact that that my extremely careful estimate (in non-inflationary days!) of the total cost was within 1% of the actual cost. It worked out in total for £5000, including 5 extra staff. The ‘package’ was approved by C.E. Branch and the Treasury, and staff were recruited in 1937. The large staff of 5 provided flexibility to keep a smooth flow of copy, proofreading, etc, to match the printer’s promised (and attained) output.

On this point, I should mention that in late 1936 the Hydrographer brought down to see me the U.S. Hydrographer, who had with him the first copy of the first volume of H.O. 214 *Tables of Computed Altitude and Azimuth*. We discussed the publication, and there was general agreement that it was too large (and too accurate) for air navigation. He left me a copy to go through in detail. That same evening, while idly turning the pages, I proofread a page and found 3 errors; on the next page I found 5 errors. Further on, I found the whole calculation of the azimuth was wrong. It was a terrible example of table-making. Working at the explanation, I discovered a systematic error; the difference for declination was given for the actual value of the declination but the precepts and the interpolation table itself were given for the excess of the declination. After some further checks, by Scott, the next day, I gave a summary of my findings to the Hydrographer, and asked him to convey my comments to U.S. Hydrographer by cable. The first edition of H.O. 214 was formally withdrawn, but, being wary of Comrie’s position in criticising the *Manual of Field Survey*, I did not publish my comments.

I.A.U. General Assembly in Stockholm in 1938

I attended the General Assembly of the I.A.U. in Stockholm in 1938 — for the first time as a full member. Comrie was still President of Commission 4, and this could have been awkward. I certainly tried to give him appropriate credit for the massive work he had done for the Office, and also in inaugurating the cooperation that led to the publication of the annual volume of *Apparent Places of Fundamental Stars* (A.P.F.S.). We had much discussion of the proposal — made by Comrie — for the combination of the apparent places of stars in one volume, instead of the duplication involved in the separate publication in various almanacs. I drew up a programme by which I proposed a limit of 200 stars in the individual almanacs while the apparent places of all the stars in the FK3 (1535) would be given in a separate volume to be prepared by the N.A.O.. Since all the apparent places of stars were interchanged freely between the offices of the five nautical almanacs, this meant a marked diminution in the work of each. I had previously made proposals with the Astronomer Royal and with H.M. Stationery Office in respect of the new publication. Admittedly, I had only carried out Comrie’s concept in practical terms.

One snag threatened to force a revision of the programme. Professor G. Fayet of the *Connaissance des Temps* said that his office could not take on the work of calculating apparent places of stars. This was countered by an offer of the U.S.S.R. Institute for Theoretical Astronomy to supply them. I accepted the offer — and undertook to provide an explanation in Russian, in addition to those in English, French, German and Spanish. I ventured to think that my ready acceptance of their offer contributed much to the subsequent good relations between the Offices.

As President of Commission 4, Comrie arranged discussions on astronomical navigation and mathematical tables — subjects not usually mentioned at I.A.U. meetings — primarily to mention the work being done by his Scientific Computing Services Ltd. I reported on the ephemerides for air navigation with a sample page of the *Air Almanac*; and mentioned the A.N.T.s. Comrie poured scorn on the A.N.T.s, and gave particulars of his own *Sea and Air Tables*, which I subsequently described in a review as one of the finest navigation tables that I had seen. It was a masterpiece of table-making, and, unlike the majority of such tables, it was completely accurate. But like the A.N.T.s it was soon overtaken by other — sometimes more crude — tabulations.

Comrie proposed a resolution recommending publication of the 7- and 8-figure trigonometrical tables, which he, in association with J. T. Peters of the Astronomisches Rechen-Institut, had prepared, and for which copy was in the Office. The 8-figure table was almost complete, but the 7-figure table required some detailed work. They had been impounded by the Admiralty as having been done by N.A.O. staff paid by the Admiralty. Peters wanted publication, and I tried hard to get Admiralty to authorise publication by H.M.S.O. or to allow some other organisation (such as the Ordnance Survey) to do so. I failed — it was a big task to print a 900-page book which neither side was prepared to pay for. Peters replied to me that he could provide the finance for the 8-figure table. So it was eventually agreed to allow Peters to publish the 8-figure table in Germany, leaving us with complete freedom to publish the 7-figure table as and when we could. It was also agreed that I should take the 8-figure table to him, and keep the 7-figure table in the Office, in the hope of subsequent financial help. I took the whole copy with me to Stockholm, but returned via Berlin, where I handed over the copy to the Director of the Astronomisches Rechen-Institut, Professor A. Kopff. The *Achtstellige Tafeln* were published shortly before the war, and there was great demand for it from the War Office. It was then photographically reproduced. I cannot remember, but it may have been my copy that was used!

Once the 8-figure table was available, there was no demand for the 7-figure table; I tried at various times to have it published - and eventually we wrapped it up, with a note concerning its origin, and deposited it in the Royal Society Archive of Unpublished Tables. [The Royal Society inaugurated the storage of unpublished tables at the request of the R.S. Mathematical Tables Committee, which took over from the B.A. Mathematical Tables Committee.]

A threatened dispute on copyright

I had been invited to give a paper on the applications of the National machine at the meeting of the British Association to be held shortly after the I.A.U. meeting. Two days before I left for Stockholm I received a letter from Comrie's solicitors threatening me with an injunction if I claimed credit or priority for discovering, and applying, the potentialities of the machine. Naturally, I had no intention of taking away any of

Comrie's well-deserved credit, and I ignored the letter. But I did introduce two applications of which I think that Comrie was unaware. Firstly, Carter and I had discovered a very much improved 'set-up' for differencing. [The 'set-up' gave the operating instructions together with the sequence of the 'stops' that determined the operations on the numbers in the six registers of the machine.] Secondly, we had demonstrated how we could use the machine for the solution of differential equations, such as those for anti-aircraft gun trajectories. Comrie was present, but he made no comment and took no action.

Apparent Places of Fundamental Stars

The detailed arrangements for the *Apparent Places of Fundamental Stars* (A.P.F.S.) were made by correspondence with the directors of the other national ephemeris offices (France - Fayet; Germany - Kopff; Spain - de la Puente; U.S.A. - Robertson; U.S.S.R. - Subbotin). It was a considerable organisational task for which we designed two forms. The first on which the cooperating offices were to enter the apparent places and the second on which they were to be pasted up for copy, thus obviating the making of duplicate copy. We found, however, that we had to recopy in many cases as the original copy was not of sufficient quality, and so the amount of work was greater than we had expected. The proofreading was also 'heavy', in the sense that the best check against accidental setting error was the consistency of functions and differences. We initially proposed that the first volume should be for 1940; but we soon realized that this could not be achieved — copy would have to be sent to the printer in early 1939 — and so it was deferred until 1941. The volume for 1941 was published approximately on schedule. All the arrangements for the volume, within the Office, were supervised by Richards, who was also responsible for the auxiliary data, lists, indexes, etc.; he did an exceedingly good job with great attention to 'awkward' detail, such as double stars, proper motions, etc.

Other publications

One other project, albeit a very minor one, was the preparation, duplication and circulation of an Eclipse Circular giving data for the total solar eclipse of 1940 October 1. This was undertaken at the suggestion, and under the guidance, of J. A. Carroll (who was then Professor of Natural Philosophy in Aberdeen). It contained (if I remember correctly!) central-line data for coelostat settings, and for bearings of sunrise and sunset points (for some weeks ahead of the eclipse) for ensuring that the apparatus was correctly orientated. Similar data have not been given, as far as I am aware, either before or since! Eclipse Circulars are traditionally the province of U.S.N.O., and are usually both comprehensive and elaborate.

Two other publications were prepared in this period, though they may not actually have been published until later in 1939. The *Seven-figure Trigonometrical Tables for every Second of Time* had been essentially prepared by Comrie, but required completion and editing. The volume *Planetary Co-ordinates for the years 1940-1960 referred to the Equinox of 1950.0*, which was a continuation of the earlier 1800-1940 volume, was prepared *ab initio*. The ephemerides were prepared as part of the major operation of converting heliocentric to geocentric ephemerides, and were supervised by H. W. P. Richards. The example, illustrating the use of the ephemerides in the calculation of the orbit of Comet 1933f, was calculated and prepared by Miss F. M. McBain. The proof-reading added to the already large load borne by all members of the staff.

Towards the end of the period (i.e. 1939) the amount of proof-reading each year was enormous: the N.A. of some 800 pages; the A.N.A. of 300; the A.A., eventually about 1200; A.P.F.S., about 600; 3 or 4 volumes of A.N.T., each about 300; predictions of occultations for some 40-50 stations sent out in manuscript for publication elsewhere. Each member of the staff spent about 2 hours each day on proofreading in some form, and much use was made of those outside workers (some former members of staff, such as Doak, Sprigge) whose ability was known. It would have been an impossible task forty years later, since the staff would not do such 'unproductive' work, and, in any case, it would cost too much.

Of course, we still continued to receive much data for the N.A. from other ephemeris offices, and, in return, we sent them stereo proofs of the first part of the N.A. containing the fundamental ephemerides. A. J. and S. G. Daniels undertook the responsibility for ensuring that copy for the N.A. was prepared and ready to be sent to the printer according to schedule. They could be relied on absolutely. Richards, and later Miss McBain, was responsible for dealing with the printer and for ensuring that the proofs were read and corrected, and that the routine exchanges were sent and received.

We were fortunate with our printers, C. T. Tinling and Co. Ltd. of Prescott, near Liverpool; they took over from Truscotts in 1936 or 1937 and over the years we developed a good relationship with them. Their work was good, although it was not their usual line (which was some newspapers, novels, commercial colour printing). H.M.S.O. were helpful sometimes, but kept changing the staff who handled our work as soon as we had 'trained' them in our ways.

CHAPTER 6

Procedures and moves

A comment on official procedures

It was during the period of expansion that I was first really shocked by official procedures; my strict non-conformist conscience did not readily accept the need for anything less than complete frankness and true estimates of requirements. The A.R. (Spencer Jones) strongly advised me to ask C.E. Branch for a larger establishment than I first proposed, and much against my inclinations, we did so. I seem to recall (it will be on record) that we got just about what I thought was really required. After my return from Stockholm in 1938 it was desirable that I should place the whole staffing position for approval by the Admiralty and C.E. Branch. I drew up detailed specifications for all the jobs required: preparation of *The Air Almanac* (A.A.) and proofreading; preparation of the *Astronomical Navigation Tables* (A.N.T.s) and proofreading; preparation of *The Apparent Places of Fundamental Stars* (A.P.F.S.) and proofreading, with an allowance for the loss of the preparation of some apparent places. I duly prepared detailed estimates of the numbers and grades of staff required for the man-hours involved, together with submissions to the Admiralty for approval to undertake the projects. The case for A.A. was straightforward — it was an R.A.F. military requirement — but the case for A.P.F.S. was by no means watertight; it involved considerable additional work, with the main compensating savings being made by the other four co-operating offices of the national ephemerides (France, Germany, Spain, U.S.A.). Although justified nationally (we received other benefits in return) and a considerable advance internationally, the direct benefit to the Admiralty was negligible. My submission to the Hydrographer (through the A.R.) was criticised by his Chief Civilian Assistant. He took the view (supported by the Hydrographer and the Astronomer Royal) that A.P.F.S. should not be mentioned; and that all the staff should be supplied for air navigation. He considered that a list of staff for the supply of air navigation material for the R.A.F. — without giving details of their work — would be approved without question by Civil Establishments Branch. It was! But I resented that the considerable work in preparing and proofreading A.P.F.S. went without full recognition. I learnt a lot, but I still consider that it was wrong. The submissions in detailed form that Comrie made for additional staff merely added to delay and to the number of queries made, and they led to the general air of distrust.

Move to Devonport House

The additional staff needed additional accommodation, and Royal Naval College had little to spare. There had earlier been a proposal that the Office should leave R.N.C., but no suitable alternative accommodation was offered. Comrie turned down, indignantly, the Admiralty's suggestion of a redundant warehouse in the East India Docks! The pressure eased, however, as the College was generous in making available several quite good rooms on the second floor of King Charles' block; although not directly communicating with the older rooms, they proved adequate.

At the end of 1938, or beginning of 1939, the authorities of the R.N.C. were under pressure of accommodation difficulties; they were introducing new courses and

the number of students was greatly increased. (I think that the War College course was introduced then.) They approached the Admiralty for alternative accommodation to be found for the N.A.O.. During 1939 we got offers of accommodation from a most unlikely set of sites; many possible locations, mainly in Greenwich, were inspected, but only three were seriously considered: the Trafalgar Quarters on the river bank (later turned into luxury flats, and later into a luxury restaurant); some old buildings (I think an old school) immediately east of R.N.C., now destroyed, with the site a car-park; and, finally, one floor of Devonport House, a separate part of the Nurse's Home attached to the Seamen's Hospital. We inspected it and it proved suitable, with the minimum of alteration. It provided admirable, modern office accommodation, but it took much effort to persuade the Admiralty to lease it.

I think that the original date for our moving was June/July, but the financial arrangements — which were of no concern to us — delayed the project. I cannot now recall the precise reasons for the situation in which I found myself on the day arranged for the move to Devonport House, which was only a short distance, about 300 yards, from R.N.C.. The removal vans (actually supplied by the R.N.C.) were packed, all the staff had been transferred, and I was alone in my old office with a packing case and a telephone trying to get the final Admiralty Board approval that had been promised each day for the past ten days. I do not like moves at the best of times, even with the optimum arrangements, and I must have been in a terrible temper. I telephoned in succession to all those, in ascending order of seniority, who were directly concerned, and I received only promises. In desperation, I then rang the Principal Under Secretary, who was very annoyed — he was impolite, saying that he could not be troubled with such a matter — but he listened to what I had to say and promised action. I got the approval within the hour!

We were only in Devonport House for a few weeks (with much material still unpacked, or unsorted) before we were evacuated early in September 1939 to Bath.

Evacuation to Bath

During 1939 everyone realised that war was a probability and that large-scale evacuation of London and other large cities would be necessary. Many of the staff took courses in Passive Defence at Woolwich. From confidential reports it appeared that the Admiralty had made no plans for the evacuation of the N.A.O.. Discussions with the Hydrographer were indecisive, so I asked permission to try to make my own arrangements. I therefore got in touch with Sir Arthur Eddington, the Director of the Cambridge Observatory, to enquire about the prospects for taking on the Office in the Observatory. He invited us to visit him, and accordingly Miss McBain, Dr. H. R. Hulme (a Chief Assistant at the Royal Observatory) and I drove to Cambridge to inspect the site. It was rather cramped, but we provisionally made arrangements with him to occupy rooms at the Cambridge Observatory that would otherwise not be required during the war. We also looked into the question of staff accommodation (billeting), and concluded that, in spite of the difficulties, arrangements could be made reasonably. We returned to find a telegram telling us not to go to Cambridge; we duly reported this to the A.R. and the Hydrographer. The A.R. had, I learnt later, made alternative arrangements for himself and his staff in Abinger, where the Time Department moved to.

Within a few days, and only a few days before war was declared, the Admiralty instructed us to report to "town AA9" to join the Hydrographic Department at the

Admiralty's evacuation headquarters. I was informed that AA9 was Bath, but was not permitted to tell the staff; they were instructed to report to Paddington Station, with railway warrants made out to AA9 and with a minimum of luggage. Fortunately, the staff found out about AA9, for at Paddington — where the vouchers for AA9 were to be exchanged — no one knew what AA9 represented! But there was a special train to Bath.

We had not been in Devonport House for very long, only a matter of weeks, before we received our orders to move. I had asked for transport to carry files and papers — and particularly the National and desktop calculating machines. Our instructions, which were common to all Admiralty departments, were that we should find tables and chairs etc. in the new offices at AA9. Stringent conditions were set on what could be taken: no desks or chairs, no bookcases, no cupboards — in fact only the papers upon which the staff was working were to be taken. On the morning we left, a large van drew up at the entrance, and all the staff agreed to fill it with furniture in addition to the machines and papers. We worked very hard, as we had to catch the train at Paddington, and the van driver wanted to get away. Some of the material was loaded before the staff left for AA9; all helped in a hurried scramble to parcel, and label, papers and to load them, using the tea trolley to move them along the corridor to the lift. But the 'strong men' — Carter and Smith certainly, possibly Harding and Grimwood — stayed behind and loaded all the furniture, which proved to be an enormous help. They certainly did a fine job! They were well helped by our messenger (who was really classed as a labourer), Farrer, who chose to come with us; although he liked his beer and was not the most politely-spoken of men, he was genuinely fond of the Office and of the staff. We were able to take almost all the furniture (desks, tables, chairs, bookcases), but it was not possible (and it had been specifically forbidden) to take other than essential, current files, records, etc.. As a consequence, a considerable mass of old calculations, files, records, pictures, etc. was left at Devonport House for subsequent removal and storage at the Royal Observatory. The arrangement was that the R.O. would remove everything that we left behind, since we would evacuate the whole office. The items left behind were stored in the old "New Library" building, which had long been used as a general store; it was damaged during the war and some material was destroyed. (None, as far as is known, was of great importance as it was mainly old calculations, proofs, etc.) Circumstances were not conducive to the making and keeping of records of what went where.

I travelled by train with the rest of the staff. They were all pretty cheerful — possibly in that we had a good friend (Helen Howard) as Billeting Officer in Bath. Fortunately, Miss Howard had been recalled to Hydrographic Department a few days before to act as Billeting Officer for the Department at Bath. She had a most difficult task, but coped extremely well and was able to ensure that the N.A.O. staff had reasonably satisfactory billets. Each member of the staff has some story to tell about his or her experience in billets in Bath. The comradeship among the girls, who were in their teens, was tremendous — as exemplified by the fact that over 40 years afterwards they are still excellent friends.

Appointment as Secretary of the R.A.S.

In the second half of 1938, I was surprised to be approached by the Chief Assistant at the Royal Observatory, W. M. H. Greaves, who had just been appointed Astronomer Royal for Scotland, with a request to act as deputy for him as Secretary of

the Royal Astronomical Society. In 1938 I was a member of the Council, and Greaves and I often discussed R.A.S. matters when we met (we played bridge). When he accepted the post of Astronomer Royal for Scotland in 1938, he proposed to Council that I should be acting secretary, and later that I should be nominated as Secretary of the R.A.S.. Greaves as he realized that he could not travel every month to London. He would retire in February 1939, and he assured me that it was the wish of the Council that I should take his place. I consulted the A.R. about taking the appointment, and he agreed that I should. Greaves was Comrie's brother-in-law as they had married sisters. His excuse in asking me was that I had found reading *Monthly Notices* very heavy since it was becoming all astrophysics and little classical astronomy; he said that as Secretary I would *have* to read the papers!

I was duly elected in February 1939, and thus had my share of responsibility during the war for the actions necessary to safeguard the property of the Society and to ensure, as far as practicable, the continuance of its activities. There was little to do for some months, since Greaves handled the papers in cooperation with H. H. Plaskett, the other Secretary. All I had to do was represent Greaves at Council and at Ordinary Meetings. However, the prospects of war grew worse as 1939 progressed, Plaskett was called up as reservist and sent to an artillery battery, and I was left to deal with all the normal secretarial work and to cooperate with the Treasurer in dealing with the security of the R.A.S. premises. The President, H. C. Plummer, was ill in Cambridge. The full story is told in my section of the history of the Society, covering 1939-1952. {Sadler's account of "The decade 1940-50" is in *History of the Royal Astronomical Society, volume 2, 1920-1980*, pp. 98-147, and his photograph faces page 98. Ed. }

It was always my intention to separate my work for the R.A.S. from that for the Office, except on the full day, once a month, for the Council and Ordinary Meetings. But this did not work out. I had to make several visits to London in the summer of 1939, and thereafter when in Bath I had of necessity to take all Friday and Saturday, once a month, for R.A.S. business. I managed to do some other work (such as that involved in the Admiralty Computing Service), but this was the pattern. I had kept on my bedroom in London and, due to the cooperation of the staff of the R.A.S., I was able to cover all the 'post-agenda business' from the Council meeting before catching the 6.50 from Paddington to Bath on Saturday evening. I resigned the secretaryship of the RAS in 1947 in order to give me more time in the Office. By then, I had a co-secretary (W. H. McCrea) who could take on my work for the Society. During my time in Bath, being a bachelor in a 'billet', I devoted every Sunday, apart from tennis in the morning, to R.A.S. work. I shall not mention again the work for the R.A.S..